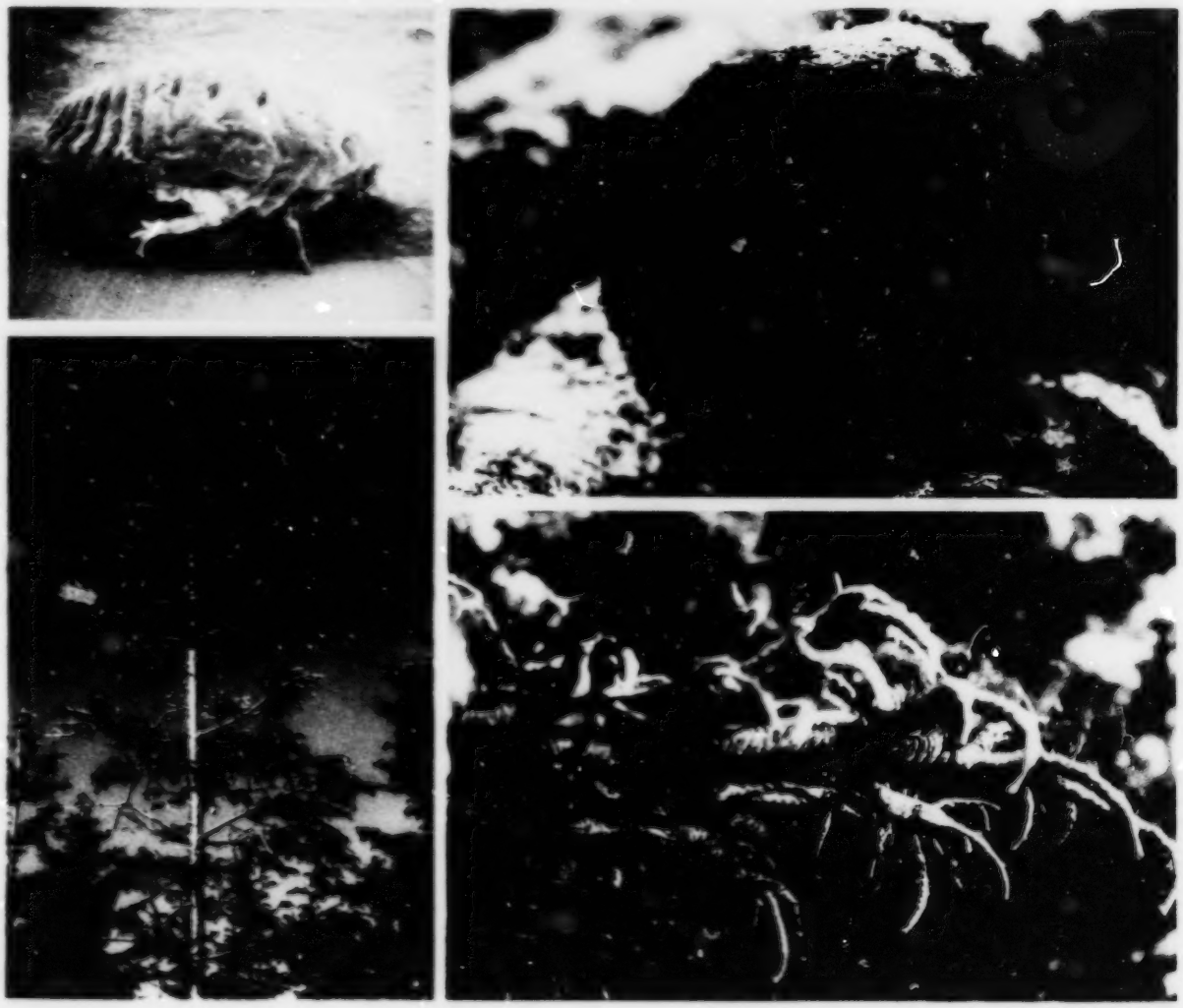
An economic analysis of the treatment of balsam woolly adelgid in Newfoundland

Grant R. Milne

Newfoundland and Labrador Region • Information Report N-X-277



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COVER PHOTOS

COVER PHOTOS

Counterclockwise from top left:

Balsam woolly adelgid, adult
Infested balsam fir - managed stand
Branch damage / dieback
Cross-section of balsam fir showing compression wood

AN ECONOMIC ANALYSIS OF THE TREATMENT OF BALSAM WOOLLY ADELGID IN NEWFOUNDLAND

by G.R. Milne

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Abstract

The risk of economic losses from the balsam woolly adelgid in precommercially thinned fir stands appears low in stands with light or moderate infestation. However, more research is needed to predict impacts over time, especially at the stand level. Economic comparisons cannot be made between precommercial thinning and site reclamation followed by stand conversion because of their different time horizons until timber maturity. Each treatment addresses different wood supply objectives. On its own however, site reclamation followed by stand conversion is not economic with current techniques. The underlying policy issue of forest tenure hinders progress in ameliorating the effect of the adelgid.

Résumé

Les risques de pertes économiques attribuables au puceron lanigère du sapin dans les éclairicies précommerciales practiquées dans des peuplements de sapin paraissent peu élevés dans les peulpements peu ou moyennement infestés. Toutefois, seule une recherche plus poussée pourra en établir les effets à long terme, sutout au niveau du peuplement. Sur le plan économique, l'éclaircie précommerciale et le reboisement suivi de conversion des peuplements ne se comparent pas, compte tenu des périodes différentes auxquelles les arbes arrivent à maturité. Chacun de ces traitements correspond à des objectifs distincts d'approvisionnement en bois. Cependent, envisagé en tant que tel, le reboisement suivi de conversion des peuplements ne se révèle pas économique avec les techniques en usage à l'heure actuelle. Des questions reliées au mode de tenure des forêts entravent l'adoption d'un meilleur plan de répression du puceron.

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1.0 INTRODUCTION

The balsam woolly adelgid, Adelges picea (Ratz.), was accidentally introduced from Europe into North America at the turn of the century and the insect was first recorded in Newfoundland in 1949 (Schooley and Bryant, 1978). The insect is a potentially serious threat to balsam fir Abies balsamia (L.) Mill. forests, particularly in coastal areas of western Newfoundland where fir is the predominant commercial tree species. Forest managers are concerned that investments incurred to thin juvenile fir stands may be at risk to severe adelgid damage. A related concern is the difference of opinion among foresters as to the appropriate technique for managing the adelgid problem. Some foresters favour precommercial thinning of juvenile stands with low to moderate insect population levels, but others favour site clearing and stand conversion to alternate tree species. These concerns exist under the spectre of current and future timber supply problems. Intensive forest management practices to reduce the impact of supply constraints on the forest industry have been greatly expanded in Newfoundland over the past 15 years. The adelgid problem, therefore, merits close attention in terms of its potential impact upon forest management practices, industrial wood supplies, and ultimately forest policy.

Effective decision-making and policy formulation regarding the balsam woolly adelgid require sound information on the insect's physical impacts upon the forest resource. This information is necessary to determine appropriate forest management responses. These responses also encompass an economic dimension. Information is therefore required about the economic effects of the insect upon the

forest; both current and future. Also, the various management options should be subjected to an economic analysis to identify the most efficient strategies.

This report assesses several key components of the adelgid problem. Section 2.0 describes the importance of forestry in Newfoundland and in particular, the benefits generated by the forest industry. Section 3.0 discusses current forest management issues in Newfoundland. The adelgid problem is described in Section 4.0. An economic evaluation of the adelgid problem is presented in Section 5.0 in relation to precommercial thinning and site reclamation. As well, other major economic impacts are considered. Finally, a number of underlying policy issues are discussed in Section 6.0.

2.0 THE IMPORTANCE OF NEWFOUNDLAND'S FOREST SECTOR

Forest resources can generate a range of values relating to the social and economic goals of man (Johansson and Lofgren 1988). Consumptive values arise through the extraction of resources from forest land including timber, wildlife and berries. Nonconsumptive values exist through activities such as scenic appreciation, bird watching and viewing wildlife. Another value arises from the indirect viewing of forest resource outputs in books, movies or television. Finally, society may value the forest resource simply by knowing that a particular type of flora or fauna exists.

Newfoundland's forests generate all of these values in addressing social goals relating to our biophysical environment. Forests provide areas for recreation and a retreat from urban life. Forests also contribute to social welfare in less recognized ways; for example by

providing favourable habitat for wildlife. Another social function is protection from erosion, especially in areas where landslides or avalanches are a threat (Papanek 1981). Forests can also be managed to influence water flow and thus provide partial control over flooding. An additional forest function is the recycling of air and the return of oxygen to the atmosphere. Another important role in Newfoundland is protection from wind. The values associated with these social functions are difficult to quantify.

On the other hand, values generated by the forest's contribution to economic goals are well documented in Newfoundland. The forest industry is a major component of the provincial economy and is concentrated on the Island. The industry is comprised of three large pulp and paper mills, approximately 1,400 small, commercial sawmills and planing mills, 78 small converted wood product plants, and a supporting logging sector. Also, a wood energy sector has emerged in recent years to supply commercial and residential users of forest biomass. Approximately 44% of all Newfoundland households burn fuelwood (Northland Assoc. 1984). An estimated 5,160 person years of direct employment exists in the Newfoundland forest industry (Table 1).

Direct forestry employment is augmented by indirect employment generated in other sectors of the provincial economy through linkages with forestry activity. For example, indirect employment is created in the service and repair sector, shipping, and petroleum products industries. For Newfoundland, each person year of direct employment in forestry is estimated to create an additional 0.70 person years of indirect employment within the province (Jacques 1988). Therefore, total indirect employment is an estimated 3,612 person years. The

direct and indirect forestry employment of 8,772 person years represents 5% of the total employed labour force in the province.

Table 1. Forest industry employment, Newfoundland 1987

Forest Industry Sector	Employment (person-years)
1. Logging	1,400
2. Wood Industries	1,195
3. Pulp and Paper	2,400
4. Biomass Supply	165
TOTAL	5,160

Source: (Cabinet Secretariat 1988; Northland Assoc. 1988)

The forest industry is dominated by the three newsprint mills. Nearly 70% of logging employment is for pulpwood production. The pulp and paper sector generates approximately 20% of the gross domestic product (GDP) arising from manufacturing activity in Newfoundland. Newsprint shipments abroad account for 25% of all provincial exports. Forestry is important throughout Newfoundland. The industry is the principal economic base in three of the five major urban centres on the Island. Throughout the province, forestry employs more than 10% of the labour force in one out of every five municipalities.

Clearly, both forest resources and the forest industry are of great importance to all Newfoundlanders. Directly and indirectly, forestry makes a significant contribution to economic and social welfare. To maintain this role however, the stock of forest resources must be sustained at a level which will ensure an uninterrupted flow of timber and nontimber outputs. This axiom is notably critical for the Newfoundland forest industry. To remain competitive in world markets

for newsprint and local markets for wood products, a long term supply of economically accessible timber is necessary.

3.0 CURRENT FOREST MANAGEMENT ISSUES IN NEWFOUNDLAND

3.1 Wood Supply

The main issue underlying the adelgid problem is the uncertainty of future wood supplies to the forest industry on the Island. The question of wood supply partially evolves from the unique characteristics of commercial forests. In Newfoundland, the estimated rotation age for managed balsam fir stands is between 50 and 60 years. Such a long maturation period has several implications regarding the stock and flow features of forest resources. At any one time, the forest stock is relatively fixed. The flow of timber available for commercial harvesting is normally limited to the annual allowable cut (AAC) under given timber utilization levels and policy constraints such as sustained yield (Lyon and Sedjo 1983). As the time horizon is lengthened, the timber supply as defined by the AAC becomes more flexible. Intervention in the form of intensive forest renewal and improvement, increased forest protection, and land use policies to expand the commercial forest land base, will augment the forest growing stock. An expanded growing stock can then allow a higher AAC.

Conversely, a catastrophic loss of the forest growing stock, for example by fire, insects, disease, or wind will reduce the AAC. The AAC will remain at a lower level until the forest growing stock is rebuilt through expanded silvicultural investment; a process which can take many decades. Newfoundland has endured serious losses to the forest growing stock, primarily from spruce budworm defoliation between

1972 to 1983. Approximately 484,300 hectares, containing nearly 30% of the Island's productive softwood volume, were damaged by the budworm (Milne 1986 a). The volume of timber in these stands is equal to about 20 years of wood supply to the forest industry. Budworm killed trees only yield a commercially useful product up to five years following mortality. Thus most of the dead and dying timber will not be harvested before deterioration (Raske and Sutton, 1982). This problem is compounded by more recent forest losses from other influences such as the balsam woolly adelgid, the Eastern hemlock looper Lambdina fiscellaria fiscellaria (Guen.) and fire.

These forest depletions, coupled with an age class imbalance in the 40 to 60 year category, have had a major impact upon the AAC estimates for the Island. The Royal Commission on Forest Protection and Management (Poole et al. 1981), identified a softwood AAC deficit of nearly 900,000 m^3 by the year 2020.

The recent Provincial 20 year plan (Forest Management Branch, 1989) estimated a current supply deficit of nearly 570,000 m^3 on the Island, increasing to nearly 750,000 m^3 by the year 1994. The longer-term outlook (after 2040) is more positive however, as earlier intensive forest management efforts begin to yield merchantable timber. These revised estimates of timber supply were based on greatly improved inventory information and modelling capability than in the past.

Clearly, the forest industry faces difficulties with future wood supply. Given the predominance of the newsprint industry in Newfoundland's forest sector, the long-term pulpwood supply is of greatest concern. The Corner Brook mill in western Newfoundland has the most optimistic outlook with only a temporary and relatively small

supply problem developing early in the next century. The supply situation for the Stephenville mill in western Newfoundland and the Grand Falls mill in central Newfoundland appears less favourable.

The supply forecasts from the Royal Commission Report and the Provincial 20 year plan were based on the physical inventory available to each mill. A more realistic picture of timber supply would be painted by differentiating between the physical and economic forest inventory. A mill may have a sufficient physical supply of timber to sustain annual production, however much of the resource could be uneconomic to harvest and process using current technology. Factors such as timber size, quality, accessibility, and distance to the mill influence the cost of extracting wood from the forest stock. With a given market price for a commodity such as newsprint, and accounting for processing costs, a mill's competitive position is highly dependent upon delivered wood costs.

3.2 Forest Management Strategies

The wood supply problem on the Island has been the focal point of expanded forest management programs by industry, and both senior levels of government. From 1974 to April 1990, approximately $166 million was spent on forest management by the federal and provincial governments through a series of cost-shared agreements. These funds have improved all aspects of forest management, including silviculture, inventory, protection and access roads. The largest single component of expenditure (42%) has been for silviculture. By the end of the current agreement in 1990, nearly $70 million will have been spent on forest improvement and renewal. The newsprint industry has also expanded its silvicultural programs over the past decade through cost shared

agreements with the Province. The objective of the silviculture program is to reduce the future impact of current insect damage and age class imbalances by increasing the remaining forest growing stock through planting and precommercial thinning.

The precommercial thinning program has been substantial. From 1979 to 1987, approximately 58,000 nectares of coniferous stands have been treated at a cost of nearly $40 million (Table 2).

Approximately 82% of these expenditures occurred in the western region (management units 14 to 18) of the province. Management units 14 and 15 account for almost one third of the total thinned area. These units are the logical supply zones for the pulp and paper mills in Corner Brook and Stephenville (Figure 1). Precomercial thinning is expected to increase merchantable stand volumes available for future harvesting. By thinning stands of 15 to 20 years of age, the industry hopes to harvest higher stand volumes approximately 30 years after treatment. This approach addresses intermediate wood supply problems. Additional benefits include decreasing the rotation age and reducing the harvesting cost of the future stand. The threat of adelgid damage in thinned stands is serious. The precommercial thinning investment could be wasted if the stands are severely damaged by the insect.

The other approach used to address future wood supply problems in western Newfoundland is site reclamation (or stand reclamation) followed by conversion to species less at risk from insects. This treatment involves replacing stands rendered uneconomic by insects, fire, disease, or highgrading with black spruce seedlings. Black

Table 2. Area thinned, by forest management unit, 1979 to 1987, Newfoundland

Management Unit	Total Area Thinned (Ha.)
1	nil
2	43
3	nil
4	nil
5	126
6	nil
7	nil
8	184
9	306
10	nil
11	5,781
12	4,246
13	nil
14	6,821
15	13,057
16	3,464
17	8,229
18	15,557
TOTAL	57,814

Source: Appendix 1.

Note: Another 3,500 hectares were thinned prior to 1979, however the data were not available by management unit.

spruce appears to be less susceptible to damage from insect pests in Newfoundland than balsam fir. The site reclamation program has been of significant stature in Newfoundland. From 1979 to 1986, approximately 12,233 hectares of productive forest land were cleared at an investment of more than $14 million. Nearly 35% of the area treated is in management unit 14 (Table 3). The clearing of uneconomic stands is only the initial step in the conversion process. Follow-up treatments usually include site preparation, and planting. To bring these reclaimed plantations into a "free to grow" state, some type of stand cleaning may also be necessary three to six years after planting.

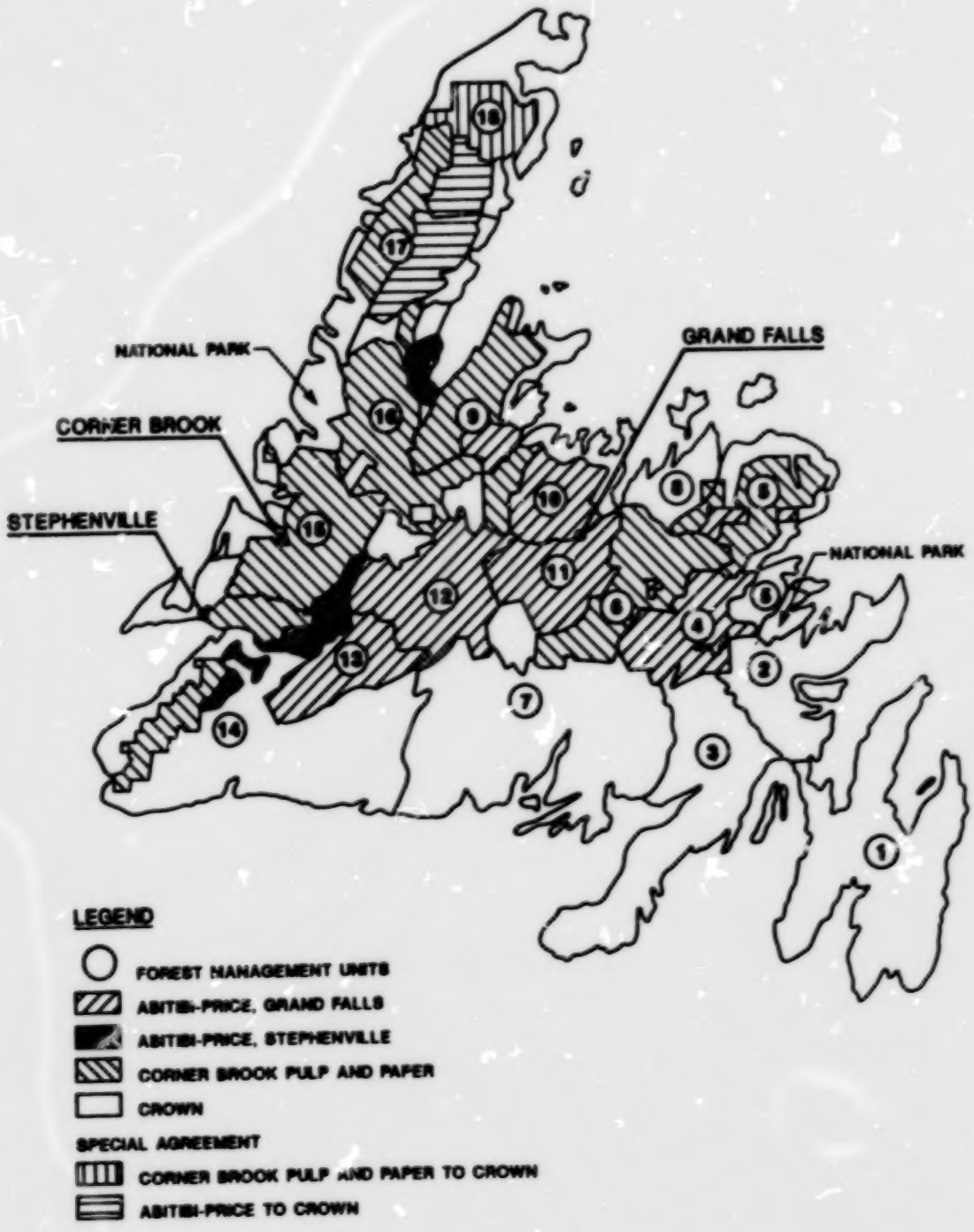

Figure 1. Forest tenure and management units, Newfoundland

These plantations will normally provide a commercial stand in 50 to 60 years with merchantable volumes exceeding those from natural stands. Thus, the program of site reclamation and conversion addresses longer term wood supply concerns. Deciding which of the above treatments is the best forest management strategy in western Newfoundland is the subject of substantial debate among foresters. The debate is complex because forest management in Newfoundland is influenced by an interrelated web of historical, political, economic, and environmental factors. Also, the issue of determining the best management strategy is complicated by the need to consider multiple objectives. One objective is to reduce the adelgid problem, especially in thinned stands or in stands which could be thinned but now have high adelgid populations. The second objective is to address the problem of sustaining future industrial wood supplies. A third objective often stated is to create employment in a province which consistently suffers an unemployment rate twice the national average.

Table 3. Site reclamation, forest management unit 14, 1979 to 1988, Newfoundland

Year	Area Cleared (Ha.'s)
1979/80	42
1980/81	395
1981/82	442
1982/83	252
1983/84	688
1984/85	1,182
1985/86	389
1986/87	520
1987/88	181
TOTAL	4,091

Source: ForCan - NLR, internal statistics

4.0 THE ADELGID PROBLEM IN NEWFOUNDLAND

The effect of adelgid damage upon mature stands of fir is well documented. In areas of severe stem infestation, the adelgid can cause tree mortality in two to three years. Chronic crown infestation can cause a tree to succumb in 10 to 20 years (Carroll and Bryant 1960). The impact of the adelgid in young stands, however, is not understood. Given that no effective insecticides are yet available to control the adelgid, the threat of damage to thinned stands must be viewed seriously. The magnitude of the problem, both in physical and economic terms, can be assessed from data. The Forest Insect and Disease Survey staff of the Forestry Canada, Newfoundland and Labrador Region (ForCan - NLR) have compiled detailed statistics relating to the physical damage caused in balsam fir forests on the Island (Appendix 1). Of the total damaged area of 160,045 hectares, 54% is located in the western region of the Island. This area encompasses management units 14 to 18 plus Gros Morne National Park. Two of the units most affected by the adelgid are units 15 (21,714 ha) and 14 (51,422 ha).

Approximately 68% of the damaged area is comprised of stands less than 40 years of age. This high proportion is of concern since stands in this age class are candidates for precommercial thinning. However, the data on the classification of damaged areas tempers this concern. Approximately 77% of the affected stands are classed as lightly damaged, 14% as moderately damaged, and only 9% as severely damaged. Intuitively, a strong relationship should exist between these damage categories and the adelgid population in a stand. Thus, the lightly damaged stands probably contain low insect populations while the

severely damaged stands contain higher population levels. Forest managers are cautious about thinning juvenile fir stands containing high adelgid levels. As the data show, however, the bulk of damaged stands are in the light damage category. Thinning in these stands may not incur a high risk of serious forest damage if the adelgid population does not increase over time. Unfortunately, inadequate knowledge exists at present to predict the effect of thinning on adelgid population levels.

From 1979 to 1987, a total of 57,814 hectares of forest were precommercially thinned on the Island (Appendix 1). Of this area, less than 8% are affected by the adelgid. Of the damaged area, 64% are classed as lightly damaged, 32% as moderately damaged, and only 4% as severely damaged. These data suggest that the risk of adelgid damage in thinned stands may be fairly low for the Island; however certain parts of the Island may pose a higher risk. Management units 14 and 15 contain 92% of the thinned area damaged by the adelgid. Although two-thirds of this area is classed as lightly damaged, units 14 and 15 must be viewed as regions of concern.

5.0 AN ECONOMIC ASSESSMENT OF THE ADELGID PROBLEM

5.1 Economic Effects in Thinned Stands

5.1.1. Methodolgy and Assumptions

Very little data are available to indicate the relationship between a given level of adelgid damage in a thinned stand and the impact of damage on future stand volume. Therefore, a number of assumptions are required about the physical impact of the adelgid on an

average stand. As well, assumptions on timber values and the response of stands to precommercial thinning are necessary.

This report assumes that on average, balsam fir stands in units 14 and 15 are situated on Canada Land Inventory (CLI) 5.0 sites. The equivalent site index from Ker (1976) is 12 metres with a gross timber volume of 191 m^3 per hectare at a rotation age of 55 years. These figures refer to healthy, natural fir stands undamage by insects. In western Newfoundland, however, few fir stands are undamaged. More realistically, a stand of fir left unthinned is assumed to yield only 80 m^3 of merchantable timber at the same rotation age because of overstocking, suppression, or insect damage. Thinning these stands at an early age will increase timber yields at rotation over unthinned yields. Three scenarios are used to assess the impact of the adelgid on precommercially thinned stands. For each scenario, the average thinning cost is $803 per ha; stands are thinned at 15 years, and the rotation age for thinned stands is 45 years;

<u>Scenario 1: Precommercial thinning and light or no adelgid damage:</u>

- thinned stands will yield 240 m^3 per hectare.
- the incremental volume gain is 160 m3 per hectare.

<u>Scenario 2: Precommercial thinning and moderate adelgid damage:</u>

- thinned stands will yield 180 m^3 per hectare.
- the incremental volume gain is 100 m^3 per hectare.

<u>Scenario 3. Precommercial thinning and severe adelgid damage:</u>

- thinned stands will yield 120 m^3 per hectare.
- the incremental volume gain is 40 m^3 per hectare.

The above information on thinning response, incremental gains in yield from thinning, impact of adelgid on stand yields, and timing of harvests was obtained from discussions with foresters employed by the newsprint industry and both levels of government. The thinning cost is the average cost of all thinning projects in Newfoundland during 1987. The cost data were obtained from federal and provincial government records for the 1986/1990 Canada-Newfoundland Forest Resource Development Agreement (FRDA). The three scenarios were felt to represent average conditions and forestry practices on the west coast but not every conceivable combination of site capability, stand volume, location relative to processing centres, and adelgid population. Ultimately, economic analyses should consider individual stand conditions by using advanced modelling techniques. These models are not presently used in Newfoundland, and the full range of data, for example growth and yield for managed stands, are not available. In the absence of these more advanced approaches, the three scenarios are sufficient to illustrate some general economic implications of the adelgid in thinned stands.

To assess the impact of adelgid damage on thinned stands the technique of discounted financial cash flow was used. This approach evaluates cost and revenues streams occurring over time. The most common practice is to discount cash flows to the present. The foundation of discounting is that a dollar received now is worth more to an individual than the promise of a dollar in the future. Income received now can be invested or consumed. These opportunities are foregone if the income is deferred to the future. Thus, the concept of time is important.

The selection of a discount rate for public investments in forestry has long been a subject of debate among foresters and economists. Two alternative approaches exist, each with a plethora of supporting literature. One approach is the social time preference which argues that governments should accept a rate of return on investments which is lower than in the private sector, especially for long term projects of benefit to future generations. The alternative approach is the social opportunity cost which suggests that public investments should earn the same rate of return as private investments. As a general guide, a study by Fraser (1985) for forestry in Canada suggested a real social time preference discount rate of 5% and a real social opportunity cost discount rate of 10%. Real discount rates are equivalent to a nominal rate (for example as posted in a bank) less inflation. This study presents results using real discount rates of 5, 8, and 10% to provide a sensitivity analysis as opposed to arbitrarily selecting one rate.

One of the main reasons why discounted forest resource investments in Canada often yield low financial returns is the low timber values used in the calculations. Usually, stumpage prices are applied as the measure of value. In Newfoundland as well as some other provinces, stumpage is merely an administered price which has little economic basis compared to timber prices established in competitive markets or through timber appraisals. Furthermore, two of the three pulp and paper mills don't pay stumpage under the terms of their tenure agreements. Using stumpage as the measure of timber value is therefore not appropriate. To address this difficulty, other measures of value can be used. One approach developed for Newfoundland (Milne 1986 b) is

to use the estimated value added for commercial timber, net of government expenditures for maintaining the resource base and infrastructure such as roads. This method provides a simple measure of value, from a government perspective, of commercial timber to the provincial economy after harvesting and processing. For this study, a timber value of $129 per m^3 was used. The value was assumed to remain constant in real terms ie. net of inflation, over time. Net present values for precommercial thinning were calculated by subtracting the treatment cost of $803 per hectare from the discounted value of incremental timber volumes per hectare due to thinning.

An alternate approach to assess the economic risk of adelgid damage in thinned stands was to calculate the volume of incremental timber necessary to break even on the treatment cost. In other words, for each discount rate, what is the volume of incremental timber required to yield a present value of $803 per hectare?

5.1.2. Results

Two trends are evident in the results for discounted cash flows of thinning in adelgid-damaged stands (Table 4). First, the net present values decrease as the level of adelgid damage increases. This result reflects the lower incremental volumes from thinning as insect damage becomes more severe. Second, the net present values decline as the discount rate increases. Clearly, the choice of a discount rate is a critical factor in assessing the economics of thinning with the risk of adelgid damage. Precommercial thinning can become uneconomic under conditions of severe damage from high adelgid population levels, especially at higher discount rates.

The results of the break-even analysis (Table 5) indicate that

fairly small incremental volumes are required to break-even on the thinning investment, especially at lower discount rates. The forest manager can use this approach to assess the possible risk of damage from the adelgid prior to thinning a stand. For example, with a discount rate of 8%, precommercial thinning must yield an incremental volume of at least 63 m^3 at rotation to break-even. The forest manager can judge whether this volume can be achieved given an existing or predicted level of adelgid in the stand.

Table 4. Impact of adelgid damage on the net present value/ha. of precommercial thinning in Newfoundland

Discount Rate	Net Present Value ($ per ha)		
(%)	Light/No Damage	Moderate Damage	Severe Damage
5	3,977	2184	392
8	1,250	480	- 290
10	380	- 63	- 507

Table 5. Break-even incremental volumes for economic precommercial thinning in Newfoundland.

Discount Rate (%)	Break-even Volumes (m3/ha)
5	27
8	63
10	109

5.1.3. Discussion

The results indicate that precommercial thinning is an efficient treatment for increasing future wood supplies on the Island. Severe adelgid damage and hence greatly reduced future yields are required before thinning becomes uneconomic. Economic gains from thinning are in most cases greater than the potential risk of losses from the adelgid. However, this conclusion must be tempered by reiterating that more research is needed to better quantify adelgid damage in thinned stands at various population levels. Also, more research is required on insect population dynamics to develop methods of predicting adelgid damage and hence the economic impact in a given stand.

5.2 The Economics of Thinning Versus Site Reclamation in Adelgid Infested Stands

5.2.1. Methodology and Assumptions

To address intermediate and long-term wood supply problems, both precommercial thinning and forest renewal, including site reclamation, may be appropriate silvicultural techniques within a forest management program. A recent report (Silviculture Technical Advisory Committee 1988) reviewed the site reclamation program and indicated that approximately 40,000 hectares of insect damaged or moribund stands exist in management unit 14. A common feature of these stands is the low merchantable timber volumes; often less than 60 m^3 per hectare. For stands where precommercial thinning is not an option due to stand age or volume, the only alternative to bring the land into commercial production is through site reclamation followed by the establishment of a new tree crop. Foresters with Newfoundland's Department of Forestry and Agriculture estimate that approximately 10,000 hectares from the

total of 40,000 hectares of damaged stands can only be treated by site reclamation and reforestation. Clearly, site reclamation and renewal may be justified from a biological or technical view, however, the question of economic efficiency still remains.

The discounted net financial returns of site reclamation in non-merchantable balsam fir stands followed by conversion to black spruce plantations were derived for average site conditions in western Newfoundland. The estimated cost of site clearing, site preparation, and planting (including seedling costs) for 1987 is $1,950 per hectare (Alexander 1988). These treatments were assumed to occur in one field season. A manual cleaning or herbicide treatment were assumed to be required on all sites 5 years after planting at an average cost of $200 per hectare. A total stand volume of 240 m^3 were assumed to be available for harvest after a rotation period of 55 years. The same timber value and discount rates were used as in the analysis of precommercial thinning.

Another analytical approach was to calculate the break-even cost of this treatment in relation to the timber values, similar to that used for precommercial thinning in Section 5.1.

5.2.2 Results

Site reclamation is uneconomic except at the lowest discount rate (Table 6), however, the values do not cover every possible combination of site and stand conditions in western Newfoundland. Changing the assumptions about stand volumes at rotation, treatment costs, and time periods, would alter the net present value estimates. However, the results are reasonable and provide a broad range of economic values.

Table 6. Net present value, site reclamation - conversion for Newfoundland

Discount Rate (%)	Net Present Value ($/ha)
5	11
8	- 1,636
10	- 1,910

The results of the break-even analysis can be viewed as the maximum cost permitted for site reclamation and reforestation in comparison to the expected economic benefits from the future timber crop (Table 7). The results provide a rough guide regarding an acceptable cost for this treatment.

Table 7. Estimated break-even costs for site reclamation and stand conversion in Newfoundland

Discount Rate (%)	Break-even Cost ($/ha)
5	2,115
8	449
10	164

The choice of discount rate has a dramatic effect upon the break-even cost for site reclamation and conversion. At a discount rate of 8%, the break-even cost for site reclamation and conversion is $449 per hectare. Given that current costs are in the order of $2,000 per hectare, the use of site reclamation and stand conversion as presently practiced can be questioned.

5.2.3 Discussion

Site reclamation and subsequent stand conversion are uneconomic according to traditional financial accounting. However, several arguments exist in support of this treatment. The estimated 10,000 hectares of candidate forests in unit 14 cannot be thinned or commercially harvested using current technology. Some type of clearing and reforestation is required to bring this area back into production. A future forest could eventually provide more than 2 million m^3 of timber to the newsprint mills in Stephenville and Corner Brook. Also, stands of black spruce would be less susceptible to damage from insect pests currently found in Newfoundland. Another point often made is that employment is created when manual site reclamation is used.

Economics cannot be entirely ignored. Funds are limited in both the public and private sectors. Silvicultural investments should be allocated to treatments generating the highest present value of net benefits. The potential costs of rehabilitating 10,000 hectares are daunting. As an example, treating just 1,000 hectares per year at approximately $2,000 per hectare results in an annual expenditure of $2 million. The present value of treating 1,000 ha per year over 10 years would be approximately $13.4 million at a real discount rate of 8%. Logically, the costs of treatment should not exceed the potential benefits as represented by various measures such as stumpage, value added, gross product revenues, etc.

Employment creation is an emotive issue in Newfoundland. However, for operational forest management programs, objectives of economic efficiency and creating jobs are often opposing. To increase efficiency usually requires mechanization at the expense of employment.

An important consideration is the economic cost of not treating these productive lands. Assuming commercial forests were established on this area and intensively managed, the future timber crop would represent a low cost source to the nearby newsprint mills. By not treating these lands, industry could face longer hauling distances and hence higher wood procurement costs by having to harvest more distant stands. An alternative point to consider is that funds could be invested in current cutovers to increase yields such that the site reclamation might not be required to sustain long term wood supply. These kinds of economic questions demand an anaylsis spanning more than one rotation and detailed information on economic timber supply. This type of analysis should be developed in the future as suitable data become available.

Assuming some site reclamation and stand conversion is required and can be justified, the net cost must be reduced. Possible approaches to explore include clearing the site by prescribed burning, using natural regeneration instead of planting, paying domestic cutters a nominal rate to clear the sites, and using the biomass commercially as an energy substitute or for newsprint production. Prescribed burning was recommended as a silvicultural tool to ameliorate adelgid infested fir stands in Newfoundland three decades ago (Frost 1958). New technology such as whole tree chipping may emerge as an efficient harvesting method for these degraded stands. The issue of employment can be addressed by separating operational forestry from employment or "make-work" programs. In these latter programs where job creation is the prime objective, manual site reclamation ranks high in terms of

person-days/ha compared to most other silvicultural treatments (Cabinet Secretariat 1984).

5.3 Other Economic Effects of the Adelgid

The concern with possible adelgid damage in thinned stands may deflect an appreciation of other problems caused by the insect. Much of the Island's balsam fir forest is infested by the adelgid to some degree. The potential volume losses must be viewed with concern given current and forecast timber supply problems. Adelgid damage can create compression wood which is a serious product defect for both lumber and pulp. Lumber sawn from logs with a high percentage of compression wood tends to be hard and brittle, warps more easily, and has inferior strength (Balch 1952). In Newfoundland, fir is the favored lumber species because of its availability on unalienated Crown forests. The Newfoundland sawmill industry normally supplies between 30 and 40% of the local lumber market. The ability to compete with imported mainland lumber depends upon both price and quality. Lower lumber quality caused by adelgid damage is a potentially serious problem for Newfoundland's sawmill and planing mill industry

The effects of adelgid damage on pulp and paper quality are more critical because of the sector's importance to Newfoundland. A high percentage of compression wood in mill furnish can result in a pulp or newsprint of inferior quality (Schooley and Bryant 1978). Balch (1955) recommended a limit of 5% compression wood in mill furnish. Trees which have been dead for three to five years can still be used for pulping (Hudak 1975), but with reduced pulp yields of up to 10% and paper strength up to 30% (Hunt 1968). Reduced yields require more fibre to produce a given quantity of pulp or newsprint. Thus, wood

costs per tonne of output will be higher than when using undamaged fibre.

The reduction in paper strength from using dead timber will result in a lower quality product of reduced value. Product quality can be improved by adding purchased kraft pulp; however, this input is an extra cost to the industry. Paper products are sold in very competitive world markets with quality a critical factor in determining a mill's competitive position. Production costs are also important. A mill cannot unilaterally increase its paper price and expect to compete. Higher manufacturing costs caused by the use of dead and deteriorated timber, and fibre with a high compression wood content are a threat to a mill's competitiveness.

Newfoundland's paper mills face a major challenge to maintain their competitive position in world markets. Newsprint markets are currently soft due to slow economic growth in developed countries and excess capacity in newsprint production. Global demand for newsprint is forecast to increase by an average of only 1.9% per annum to the year 2010 (Woodbridge, Reed, and Assoc. 1988). The competitive position of Canada's newsprint industry is a cause for concern. A study in 1986 (Koken) of six major international newsprint producing regions, ranked Canada lowest in cost competitiveness. Low productivity, and unfavourable exchange rates were major factors. In addition, newsprint production in many lesser developed countries has increased in the past several years. These countries are not only becoming self sufficient in newsprint, but are competing for a share of the market in developed regions (FAO 1986).

6.0 POLICY ISSUES RELATING TO THE ADELGID PROBLEM

The adelgid problem is important, especially in western regions of the Island. The insect has generated a debate among the forestry community in the search for effective management techniques for stands. The adelgid problem has also evoked many questions about the long term direction of forestry in Newfoundland and implicitly, about forest policy. A preoccupation with the adelgid at the stand or even the unit level, may in fact be overshadowing these more crucial and fundamental questions. The purpose of this section is to identify two key policy concerns which need to be considered by the forestry community in Newfoundland.

Policy Issue 1 - Forest Sector Strategy

Reaching a consensus among key stakeholders on future economic wood supply is a prerequisite for improved strategic planning in the Newfoundland forestry sector. The problem of insect damage over the past several years may be acting to focus planning efforts on the short to intermediate time horizons rather than the longer term of one rotation. Over this longer time period, the structure, species composition, and to a certain degree, location of commercial forests can be significantly reshaped. What are the long term goals for wood supply, industrial structure, scale and location, and the overall contribution of commercial forestry to the provincial economy? Some of these goals have been addressed in the provincial government's recent 20 Year Plan, however more work is needed. Establishing broad strategic goals can facilitate the development of well-founded programs and policies in forestry. These points are directly related to the adelgid problem and questions about the most effective silvicultural

prescriptions, priority locations for investments, and the amount of investment required. While a planning horizon of 50 to 60 years may be viewed by some people as unrealistic, many other developed countries including Sweden, Finland, Belgium, Great Britain, and the United States have successfully followed this approach.

Policy Issue 2 - Tenure Revision

Given reasonable estimates of long-term economic wood supply/demand, and strategic forest sector goals, a second key policy priority should be to review the tenure situation on the Island (Milne, 1988). Newfoundland is in the unique situation among all provinces of practicing forestry in the 1990's under a tenure system which evolved at the turn of the last century. The forest management problems created by insects such as the adelgid are compounded by a tenure structure that has historically provided low explicit timber values and little incentive for private investment in forest renewal. Investments in intensive forest management by industry during the past several years may be due more to the availability of federal funding through cost-shared agreements and fears about future wood supply rather than any economic incentive built into the tenure system.

The pulp and paper companies have traded timber for a number of years in order to reduce cross hauling and are now considering land exchanges. These actions undeniably point to inefficiencies in timber supply relative to mill location. Present licences and leases begin to expire early in the next century. The uncertainty of future ownership of these limits is not conducive to encouraging industry investments in the resource base in some parts of the Island. On the west coast of the Island, concerns have been raised by foresters that some adelgid

damaged stands are not being treated because of the uncertain tenure situation as licenses expire in the next century. Restructuring the tenure system and reallocating timber limits more efficiently could provide better stability for investment. Reform will not be easy, however constructive tenure changes have occurred with some measure of success in other parts of Canada such as New Brunswick, Quebec, and British Columbia. The present industry and provincial government cannot be blamed for creating the tenure system. The challenge is to grasp the nettle of tenure and enact positive, progressive, and equitable reforms.

7.0 CONCLUSIONS

This report examined a number of economic issues related to the adelgid problem, particularly in western Newfoundland where the insect pest has caused serious damage to fir stands. In western Newfoundland, precommercial thinning is a widely-used management prescription to ameliorate forecast timber supply constraints during the next few decades. Managers are concerned however, that the adelgid may put the investment in thinned stands at risk. Two factors should reduce this concern. First, most of the damaged stands in western Newfoundland, and indeed for the whole Island, are in the light damage category. While management units 14 and 15 are particularly hard hit, the area of severely damaged stands is quite small.

Second, according to discounted cash flows, precommercial thinning in fir stands is economic except where severe adelgid damage is likely and high discount rates are applied in the analysis. The risk of losing the thinning investment is fairly low in stands likely to suffer

only light or moderate insect damage. Prior to thinning, if forest managers can be reasonably sure that adelgid damage in stands will be light or moderate, the investment decision can be made with more confidence. However, more research is required to better quantify adelgid damage in thinned forests at the stand level and at various insect population levels. Also, a pest management model which included economic parameters would be an invaluable tool to provide information on probable levels of adelgid damage in fir. A similar model developed for the hemlock looper in Newfoundland could offer a methodological framework to build upon.

Another management issue is the treatment of fir stands already degraded by the adelgid, or other insects such as the spruce budworm. Stand reclamation was shown to be uneconomic according to discounted cash flow criteria. The treatment also does not contribute to the softwood supply deficit forecast for the next few decades. However, many of the sites occupied by these degraded stands are highly productive and close to two paper mills on the west coast. New techniques must be identified and tested to reduce the cost of clearing these sites. One option might be chipping the fibre for use as an energy source. Alternatively, if the bark can be removed prior to chipping, the material would have high value as a pulp furnish.

The linkage between the adelgid problem and forest tenure is quite strong. Tenure uncertaintly as licenses begin to expire early in the next century is causing concern among foresters that some stands on the west coast are not being silviculturally improved. This report has shown that the risk of economic losses in thinned stands is low where adelgid damage is light or moderate. Therefore, a reluctance by some

foresters to treat stands based on perceived adelgid risk may not be warranted except in limited areas of very high insect populations. This reluctance could also reflect tenure uncertainty. A review of tenure by the Province and some progress toward a more efficient structure would be benefical to both the public resource owners and the current industrial tenure-holders.

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Appendix 1. Estimated Balsam Woolly Aphid Damage vs. Area Thinned, in Newfoundland, 1987.

Unit	Balsam Woolly Aphid Damaged areas (ha)				Stand Age (ha)		Area (ha)	Area of PCT's with BWA Damage			
	L	M	S	Total	< 40	> 40	PCT's	L	M	S	Total
1	2980	495	-	3475	3053	185	-	-	-	-	-
2	13763	-	741	14504	-	14504	43	-	-	-	-
3	2159	73	408	2640	2640	-	-	-	-	-	-
5	5294	2749	1104	9147	341	8806	126	84	-	21	105
6	-	-	90	90	90	-	-	-	-	-	-
7	1521	-	-	1521	1521	-	-	-	-	-	-
8	15410	2475	4843	22728	11566	11162	184	19	-	-	19
9	3553	257	-	3810	1527	2005	306	-	-	-	-
10	2103	-	-	2103	1636	467	-	-	-	-	-
11	2824	-	1200	4024	4024	-	5781	206	-	-	206
12	4456	-	-	4456	2519	1937	4246	-	-	-	-
13	3052	-	-	3052	-	3052	-	-	-	-	-
14	34666	12548	4208	51422	45484	5938	6821	1079	1379	48	2506
15	17943	1540	2231	21714	20588	1126	13057	1352	-	100	1452
16	10629	686	-	11315	11315	-	3464	5	-	-	5
17		-	-	-	-	-	8229	-	-	-	-
18		-	-	-	-	-	15557	-	-	-	-
GNNP	2691	-	-	2691	2071		-	-	-	-	-
TNNP	-	1353	-	1353	-	1353	-	-	-	-	-
	123044	22176	14825	160045	108375	50535	57814	2745	1379	169	4293

Note: L - light damage
M - moderate damage
S - severe damage

BWA - balsam woolly aphid
PCT - precommercial thinning
GNNP - Gros Morne National Park
TNNP - Terra Nova National Park